SWITCHING A TRACKING ANTENNA

"Figuring out how to turn something on and off can be a tough problem," commented Edward Fish, engineer at Philco-Ford's Western Development Laboratories (WDL). In 1963, WDL accepted a contract to design and assemble a sixty-foot satellite tracking antenna for the military. Mr. Fish said that he was one of about one hundred engineers in the department that was to design the antenna. His particular section of the department was responsible for the design of the control system for the antenna. For example, the section was to develop a combination of devices -- such as motors and gears -- that could keep the antenna directed automatically toward a moving satellite. The WDL Programs Office, which acted as a liaison between the company and its customers, allowed Mr. Fish's section three months to complete its designs. A photograph illustrating this type of antenna appears as Exhibit 1.

Prepared in the Design Division, Department of Mechanical Engineering by Sue Hays under the direction of Ralph J. Smith and Karl H. Vesper with financial support from the National Science Foundation.

The Philco-Ford Corporation, which originally established its reputation as a radio manufacturer, began to work with telemetry and control problems at WDL in theearly 1950's. After Philco became a part of the Ford Corporation in 1961, WDL grew rapidly and by 1967 employed about 2500 people. Much of WDL's work was done under state and federal government contracts and was concerned with receiving and transmitting non-vocal information (telemetry). For example, WDL designed, built, and maintained satellite tracking stations throughout the world. They also designed a system for automatically controlling water flow and levels in a vast complex of dams, canals, and aqueducts to supply two new Northern California power plants. More recently they contracted with the Bay Area Rapid Transit District to design and install a communication system to control the movement of trains in a storage, maintenance, and repair facility.

The satellite tracking antenna on which Mr. Fish was working was to operate in four different modes. In the TRACK mode, the antenna would automatically follow a moving satellite (see Exhibit 2). In the SLAVE mode, the antenna's position would be controlled by a computer containing information about the satellite's predicted location. In the SEARCH mode, the computer would be programmed to cause the antenna to scan the sky in a systematic fashion. In the MANUAL mode, the antenna would be free to turn so that operators at the antenna site could rotate it to a convenient position for maintenance work.

The antenna's operation was to be controlled by four push buttons mounted on a panel in the tracking station control room. In describing the operation, Mr. Fish said: "When power is first turned on, operation is to be automatically in the MANUAL mode so that the antenna will not move until a button is pushed. When a mode is started by pushing a particular button, the previous mode is to be disconnected. Pushing the TRACK button, for example, must disconnect all other modes and simultaneously energize a relay (which requires 2 amperes) at the antenna site to initiate the TRACK operation. Once initiated, a mode is to continue until another button is pushed. Also, it has to be possible to select the modes in any order."

At the beginning of the tracking antenna project, Mr. Fish spent about a week writing "logic equations"* to clarify some of the numerous military "specifications" for the antenna system. He would work out an equation, then explain to the Military Programs Office what it implied about the operation of the antenna. Whenever the response was "that's not what we really meant," he would modify his equation. "If specifications are too precise," he commented, "there's no room for product improvement, but if they're too vague, customers don't always get what they want."

During the week in which he worked on the logic equations, Mr. Fish spent part of his time selecting some push-button units. "If we had needed many sets of buttons, it would have been cheaper to use mechanically operating units rather than electrically operating ones," Mr. Fish said. "Since we don't manufacture most parts used in our products, we would have had another company make the buttons for us. It might have taken quite a bit of time to write specifications for that company." Mr. Fish knew that all parts purchased for a military project were subject to military approval before they could be ordered. Also, the Philco-Ford Quality Assurance Program required a reliability inspection of all purchased parts before approving them for use by Philco-Ford engineers. He expected that these circumstances might stretch out the time needed to obtain the push-buttons by several months.

From his previous experience in buying parts, Mr. Fish remembered that several companies kept push-buttons with electrically operated holding coils** in stock. Delivery of these he guessed would take about three weeks.

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*An example of a logic statement might be: "If switch A and switch B are closed, then switch C is to be open." Logic equations use symbolic notation to express such statements.

**The holding coils hold the switch on after the button is pushed. When the switch is closed, current flows through the coil to produce a magnetic force. Pushing a different button then should interrupt the current to the holding coil and allow the switch to open again.

He recalled that his company had previously used some of these units and found them satisfactory. He decided to send for catalogs describing the buttons to see if there were any important differences. Inspecting the catalogs (Exhibit 3), he discovered that units manufactured by Buttoneer Industries* and those made by Quikswitch Company* were suitable and quite similar to each other. Both units were priced at around $20.

He also considered several "human factors." For example, the Military Specifications required that the buttons should light up when pushed down, and each button should contain at least two bulbs so that if one bulb burned out, the button would still be lit. The military also required taking precautions to prevent personnel from contacting potentials greater than 30V. According to the catalog, both button units operated on less than 30V.

Philco-Ford's Human Factors group, whose job it was to inspect all products to make sure that they would be easy for people to use, judged the button units acceptable. Both Buttoneer and Quikswitch provided removable caps in various colors for the bulbs. They also provided translucent screens which could be imprinted with appropriate legends, such as "track" and "slave". Mr. Fish noted that the legends were easy to read even when the buttons were not lighted. He decided to use green caps on the button lamps because green normally signifies an "on" condition. However, he decided to order a variety of colored caps just in case the Human Factors group would not approve of his color choice.

Upon further comparison of the catalogs from Buttoneer and Quikswitch, he concluded that it was more difficult to change the light bulb in the Buttoneer unit because a special tool was needed. The Quikswitch unit, on the other hand, could be disassembled by hand. The light bulbs could then be removed from the clips which held them. Furthermore, he

*Names have been disguised.

understood that Quikswitch had a warehouse in Los Angeles, whereas Buttoneer Industries was located in Chicago, Illinois. He therefore expected that he could get faster delivery from Quikswitch. He decided to use the Quikswitch unit.

According to the catalogs, button units came in sizes that depended upon their operating voltages. Quikswitch units operated from 6V, 12V, or 28V. Buttoneer's switches operated from 6V, 28V, or 48V. The higher voltage units were more expensive than the lower ones. The bulbs operated from 28V. Mr. Fish wanted to use a voltage that would be compatible with Buttoneer's units in case something should happen to Quikswitch buttons and he couldn't obtain replacements. He noted that strikes or high demand which could usurp a company's supply of stocked items might create such a situation. Heat dissipation was not expected to be a problem since the buttons would be surrounded by "a lot of air" when mounted in the control panel and would not be close to any other equipment. Mr. Fish decided to use button units that operated from 28V. He told his co-workers that he needed a 24V power supply. The lower voltage would give the lamps a longer life, and he thought the button relays would still operate at 24V. Relay contact deterioration would, he expected, be lower at reduced voltage.

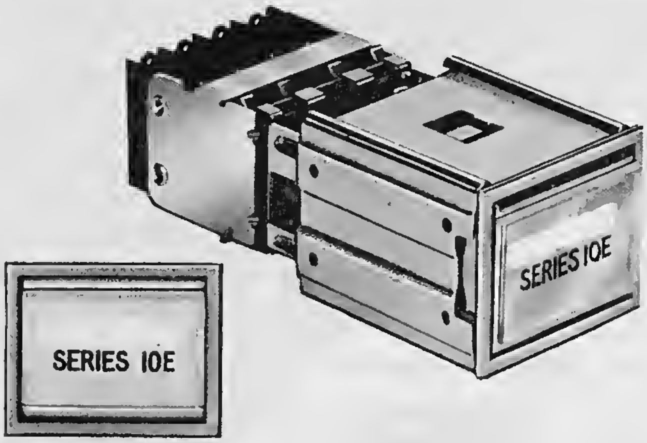
Next Mr. Fish considered how to connect the switches in the button units together so they would operate according to the military specifications. The quikswitch catalog showed that the button units were equipped with from one to four "single-pole, double-throw" switches. He hoped to use only two switches in each unit because this would simplify the wiring. He wanted to make his connections as symmetrical as possible, that is, he wanted to make the connections between the first and second buttons similar to the connections between the second and third buttons, and so forth, insofar as possible. He had seen other engineers design button connections this way and knew that a symmetrical design would make it easier to add more buttons later, if they should be needed. He thought such a design might also help prevent wiring mistakes.

"Although the logic equations clarified the specification, I had to use trial and error to determine the proper switch connections," said Mr. Fish. He regarded his problem as one of "pure and simple logic." ["It's not what you learn in school, maybe, but it's important to be able to do this sort of thing," he commented.] "In this case what you're turning on and off isn't important. It could be anything. You sit down with this kind of logic problem and you just fiddle. You fiddle until you come up with something that will work. So far, I have the TRACK and MANUAL buttons working properly and extending the design to the other modes should be straightforward." (See Exhibit 4.)

"After I've finished the circuit design, I'll have to make sure the contact rating on the switches will not be exceeded," Mr. Fish added. This rating tells the maximum amount of current that can pass through a contact without damaging it. The manufacturer's catalog lists this rating as 5 amps and says the solenoid in each unit uses 1.7 watts at 28VDC. The catalog also says that tubular, single-contact, midget-flanged lamps with bulb diameter of 7/32 inch must be used in the button units.

Mr. Fish planned to check another catalog (Exhibit 5) to determine how much current such lamps draw at 28VDC.

SERIES 10E ILLUMINATED PUSHBUTTON SWITCHES

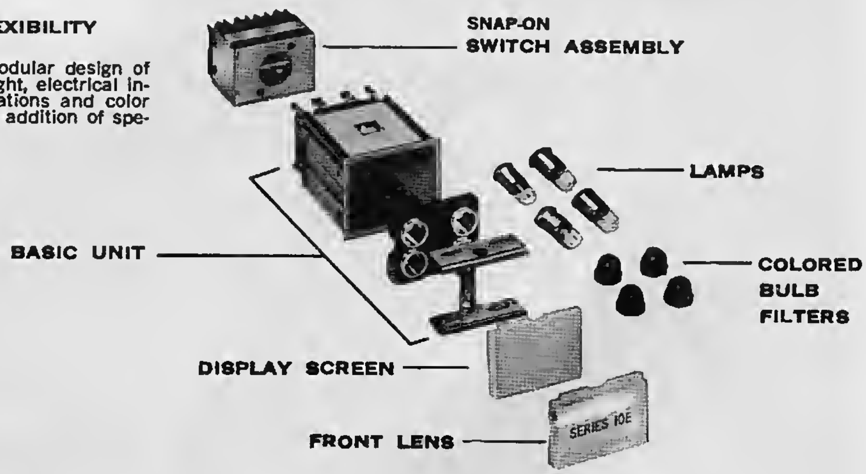


FEATURING A FOUR LAMP DESIGN, POSITIVE HARD MOUNT SLEEVE, INDIVIDUAL LAMP COLOR CONTROL, UP TO 4-WAY SLIT DISPLAY FACE.

Series 10E modular units can be used as illuminated pushbutton switches or as word indicators for design compatibility. Inclusion of a magnetic holding coil for numerous electrical interlock, lock-in and lock-out circuits gives the switch light complete capability. The four lamp design — combined with a choice of divided screens — offers many display possibilities. Depression of the front lens actuates the switch module which is available in momentary or alternate action in snap-on assemblies. Legends may be reverse engraved on the front lens at the factory for uniform readability and long wear. The special slip-on mounting sleeve provides a positive hard mount particularly useful in equipment designed for extremes of shock and vibration. Flush-mounting is easily achieved in horizontal or vertical rows, as well as matrix configurations.

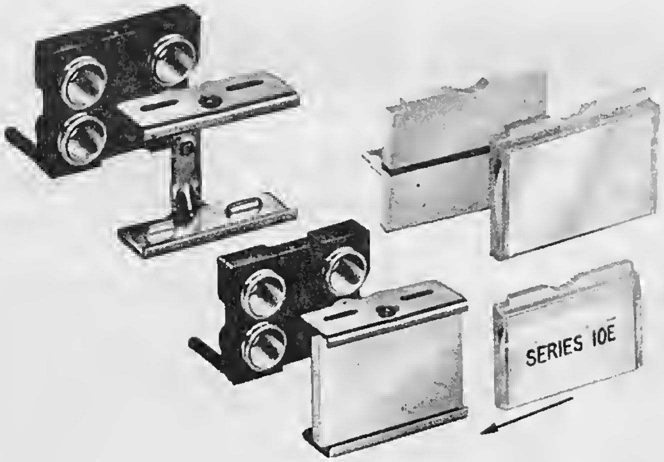
MODULAR DESIGN GIVES MAXIMUM FLEXIBILITY

Multiple functions are possible with the basic modular design of the units. Adaptations for indicator light, switch light, electrical interlocks, display combinations and color combinations and color controls can be achieved by interchangeability or addition of specific component parts.



COLORED LAMP FILTERS PERMIT INDIVIDUAL COLOR CONTROL

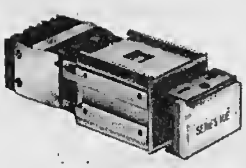
Individual lamp color control is provided by silicone rubber filters which fit over each lamp socket. These high efficiency filters are available in amber, blue, green, red, white, and yellow. The chromaticity of each color has been carefully selected to insure maximum operator response and discernibility between colors.

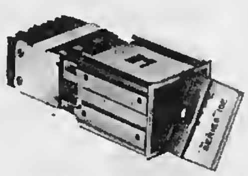


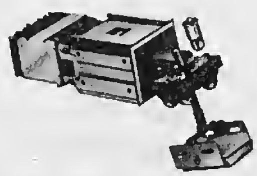
REMOVABLE FRONT LENS AND DISPLAY SCREEN

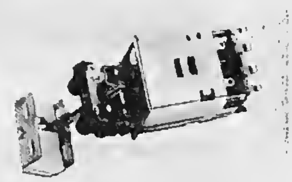
Front lens and colored filters can be easily changed from the panel front, without tools of any kind. This feature allows maintenance and modification to be accomplished quickly and efficiently. Both lens and display screen slide into the lens retainer which is connected to the actuating shaft.

No Tools Required for Relamping, Legend, or Color Filter Change from the Panel Front.









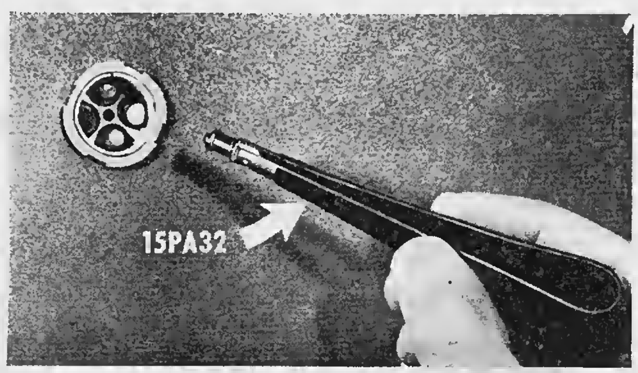
FRONT OF PANEL RELAMPING IS EASY

Lamp replacement is accomplished from the panel front without the use of tools and may easily be done without fear of accidental switch actuation. Simply PULL, TWIST and REMOVE for complete access to the lamps.

POSITIVE INDEXING

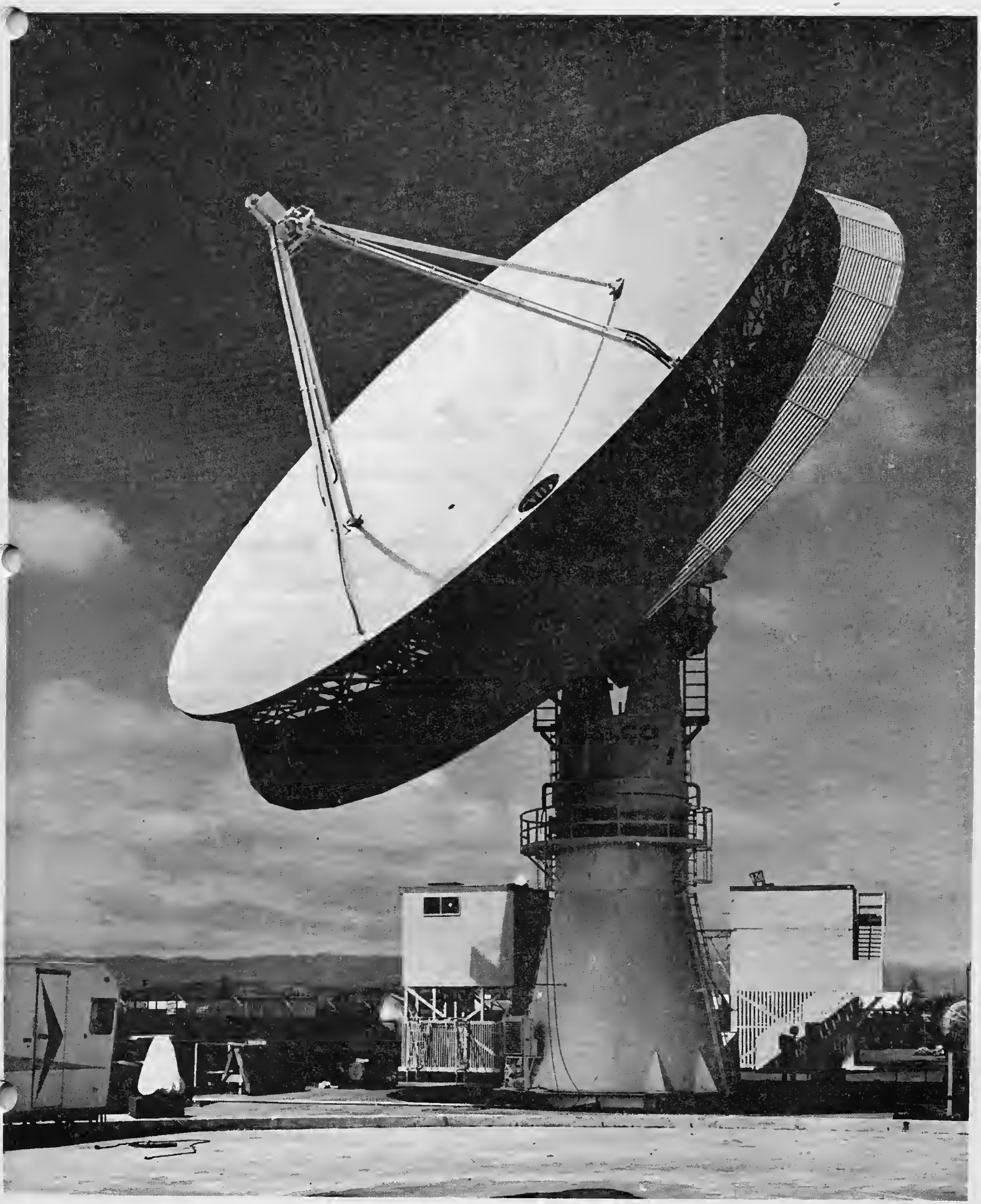
During relamping, the front end assembly remains connected to the unit's housing by two sides. This important feature precludes the possibility of inadvertently transposing the front end assembly with adjacent units.

LAMP-FILTER TOOL



This tool, Catalog Listing 15PA32, permits the changing of lamps and color filters from the front of the panel without causing breakage or shorts.

Exhibit 1. Satellite Tracking Antenna



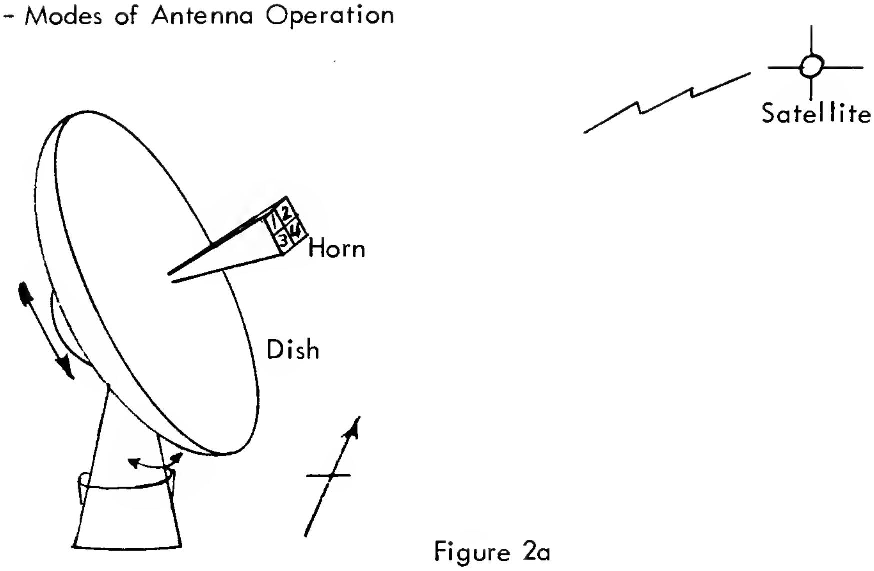


Figure 2a

The antenna or "dish" can tilt in a vertical plane or rotate in a horizontal plane. The horn (Fig. 2a) is divided into four sections that separately receive signals from the satellite. If the total signal received by sections 1 and 3 is greater than that received by sections 2 and 4, then the antenna is to be rotated toward the south until there is no difference in the signal power received. Likewise, if the signal power received by sections 1 and 2 is greater than that received by sections 3 and 4, then the dish is to be tilted upward until the difference in signal power is zero.

A device can be designed that will compare the signals received and generate a voltage that is directly proportional to the difference in signal received. (Fig. 2b.) This voltage, in turn, can be used to drive a motor. The motor will produce a torque proportional to the applied voltage. This torque can then be used to correct the position of the dish. Errors in positioning are "fed back" to the input; hence the operation is "automatic" and the antenna will track the satellite across the sky.

When the track button is depressed, some of the current through that button unit flows through a solenoid located at some distance from the control panel itself. Current in this remote solenoid then operates another relay that connects the voltage signals from the horn to the system of motors, gears, and amplifiers that controls the system.

Likewise, depressing the slave and search buttons causes the operation of corresponding distant relays that connect a computer to the control system. The manual button does not operate a distant relay since the control system is not automatically supplied with power in the manual mode.

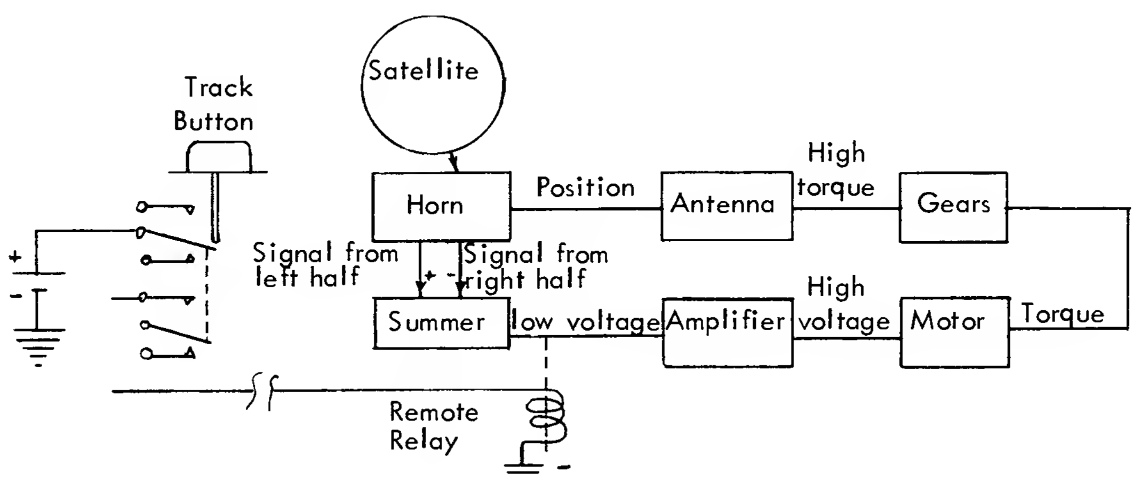
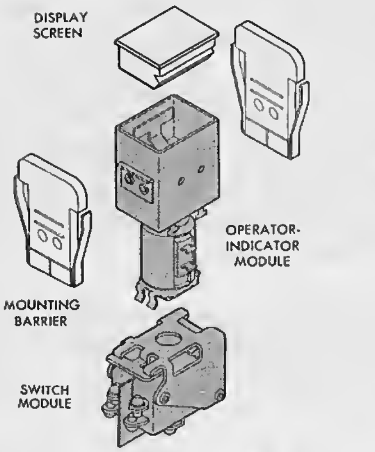
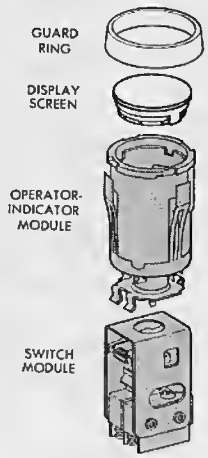


Figure 2b

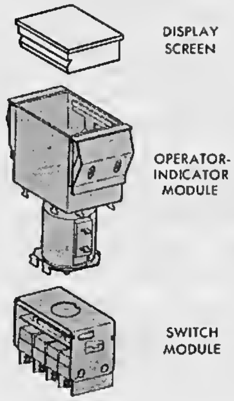
EACH MODULE HAS A SEPARATE CATALOG LISTING



RECTANGULAR BARRIER MOUNT



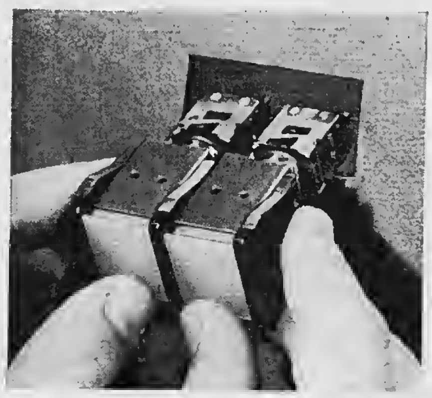
ROUND FORM



RECTANGULAR FLANGE MOUNT

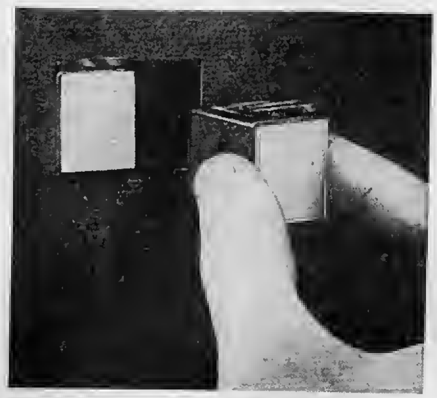
Quick, Easy Attachment to Panels

Here are three typical Series 2 devices being inserted in their respective panel cutouts. Switch units can be snapped on before the assembly is mounted, or they can be pre-wired in a harness and attached after the operator-indicator modules are in the panel.



Rectangulor Barrier Mount. Barriers serve as mounting devices and separate the display screens to prevent accidental operation. The desired number of units are combined in a strip and snapped into the panel slot.

Round Form. Four flexing spring leaves hold the round display units in the panel. Guord rings encircle the display screens from the panel front. Modules are keyed to insure proper orientation of legend moterial.



Rectangular Flange Mount. In the flange-mount systems, the mounting devices ore supplied ready-attoched to the units. When used in rows or columns, they present o continuous strip appearance, and permit an overlay panel.

Human Engineering In Panel Design

Ambient light. The contrast of the lighted display to its panel surroundings increases as the ambient light level is diminished. This will be especially appreciated with low output lamps and projected color. The angle of a panel to the dominant source of ambient light is a major factor in contrast and visibility. Glare is a factor when ambient light is derived from undiffused or concentrated sources.

Colors Used. Colors chosen for Series 2 display screens are of pleasing hue, selected to be adequately distinguished one from the other in high or low ambient lighting and at reduced lamp voltages. Amber should be substituted for yellow when used next to white, at low voltages.

Number of Lamps. Brightness will be in direct ratio to the number of lamps used. Hue tends to deepen as the number of lamps is increased.

Temperature Limits. Lamps used with Series 2 devices are rated at approximately 1 watt each and heat dissipated when lamps are energized should be considered. It is necessary to determine the ambient temperature — the actual behind-the-panel heat resulting from lamps, motors, electronic components, etc. — to which the devices will be subjected when determining the display to be used. High ambient temperatures may require that fewer lamps be used in each unit, or that lamps be operated at reduced voltage.

Special high temperature screens are available should the ambient behind-panel temperature exceed +125°F. For information contact your nearest branch office.

Panel Finish. Matte or non-reflecting finishes aid contrast and visibility. Matte black is the finish which yields maximum contrast to a lighted display of any color.

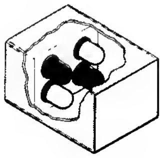
Wide Choice of Display Color and Legend Practices

TRANSMITTED COLOR

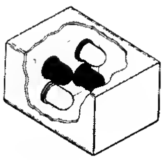
Transmitted color refers to the use of colored screens in applications that require the color to be distinguished when the display is unlighted. Over 80 different colored display screens are available. There are one-piece as well as three-piece types, with provision for a legend insert. Catalog Listings are shown on pages 19 and 20.

PROJECTED COLOR

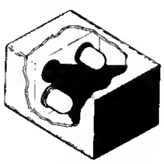
Projected color is a technique which can make display screens "change color." White translucent



Blue Filtered Lamps "On"



All Lamps "Off"



Red Filtered Lamps "On"

screens are used, and the color is supplied by filters which fit over the indicator lamps. When lighted, the filtered lamps cause the screens to take on the soft, uniform color of the filters employed. Although the illustration above shows a rectangular display device, the same effect is possible with the round form Series 2.

Up to six colors of filters are available. However, two colors in each display device, each illuminated by two diagonally spaced lamps, is the scheme recommended for most uniform illumination.

LEGEND PRACTICES

The three-piece screens with separate clear insert are easiest to label. They have a slide-on cap which protects and provides easy access to the legend material. In general, maximum contrast for greatest legibility is obtained by using black lettering on white and yellow display screens, and white lettering with the darker colors.

India Ink can be applied to the insert with a lettering guide. Commercially prepared type supplied on strips of clear acetate is very useful. The insert may also be engraved and filled, or heat stamped with legend material.

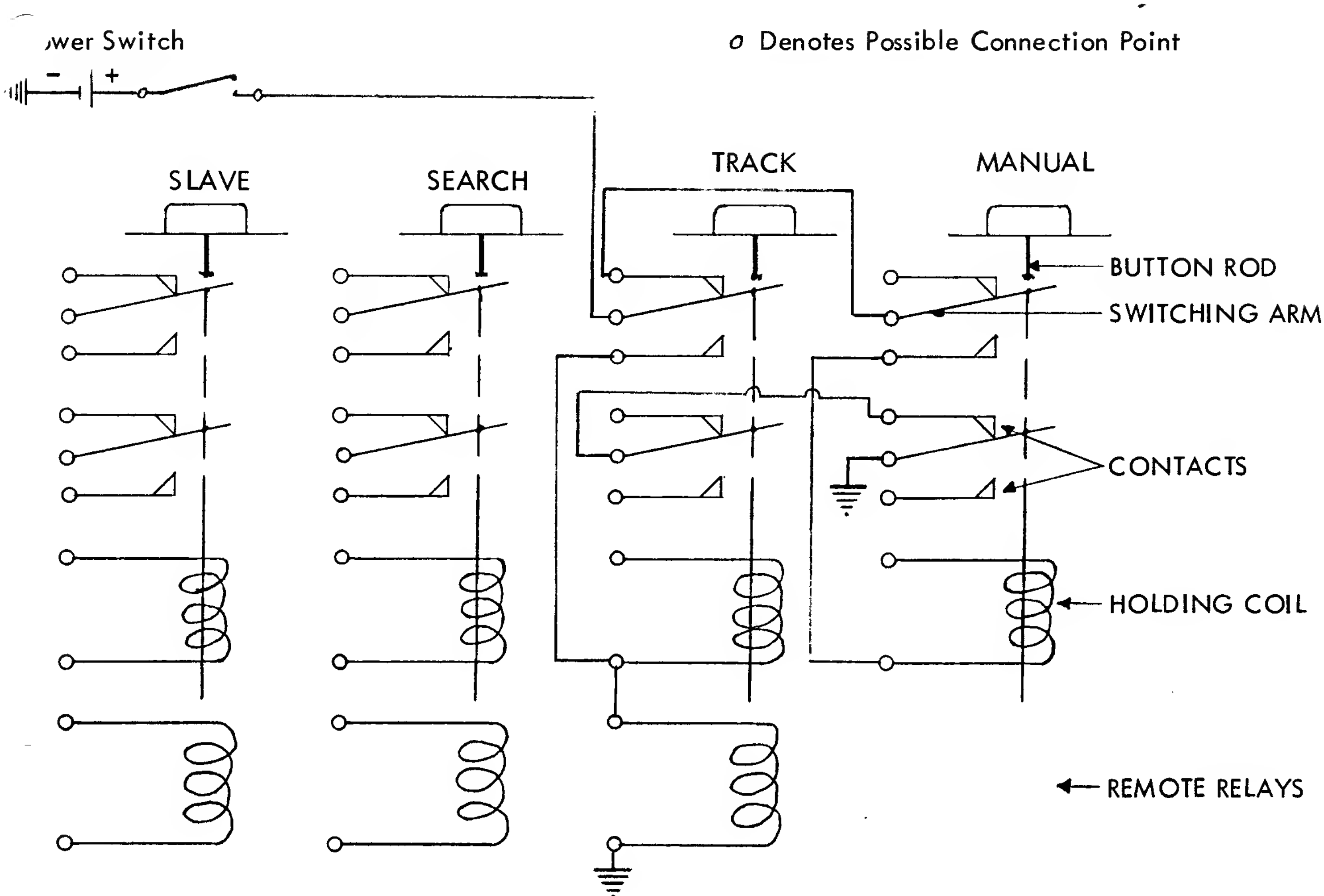
ADDED COLORS

Added colors may be included by the user on the insert portion of the screens in the form of colored lettering, colored pictographs or other symbols, to aid in coding or to overcome language barriers. Colored transparencies bearing the desired legends may be used in place of the inserts.

FILTERS

Silicone rubber filters are not affected by lamp heat. No color is noticeably brighter than any other, making these filters ideal for use under low ambient lighting conditions where the difference in apparent brightness could be objectionable.

The "blue-white" filter is useful in cutting down the brightness of a white display. It has a slightly blue tint which prevents white from appearing "yellowish" at reduced voltages.



Requirements

Condition	Lights	Mode
Power off	All off	
Power turned on	All off	MANUAL
Button A pushed	Light A on; all others off	Mode A
Button B pushed	Light B on; all others off	Mode B

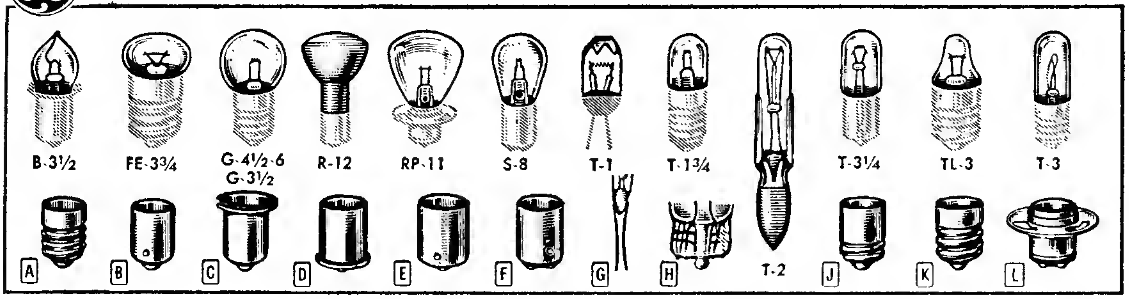
Note: Only one mode may be on at a time. Modes may be selected in any order.

Button Operation

The switching arms of these switches are normally in contact with points "A". When a button is pushed down, both its swinging arms are mechanically forced away from points "A" and against points "B" by the rod (dotted line). If current is flowing in the solenoid, the arms will be magnetically held against the "B" points until current ceases to flow. Then they will return to the "A" positions. The magnetic force caused by current flowing in a particular solenoid is not great enough to pull a button down, however. The force merely holds the button down after is has been manually depressed.

Miniature Lamps

General Electric Miniature, Subminiature Lamps



ABBREVIATIONS USED TO DESCRIBE BASE AND BULB STYLES

BASES: **D.C. Bay.**, double-contact bayonet. **D.C. Pref.**, double-contact, prefocused. **Mid. Screw**, midget screw. **Min. Bay.**, miniature bayonet. **S.C. Bay.**, single-contact bayonet. **S.C., F.**, single-contact, flanged. **S.C. Mid., F.**, single-contact midget, flanged. **Tel. Slide**, telephone slide. **BULBS: B**, lemon. **G**, globe. **FE**, flat end. **R**, reflector. **S**, straight end. **T**, tubular. **TL**, lens end, tubular.

GENERAL-PURPOSE MINIATURE LAMPS

Numbers in Bulb Style indicate bulb diameter in eighths of an inch. Example: S-8 is 8/8ths, or 1" in diameter. *Switchboard slide-type base. †Similar to bulb TL-3; ‡Similar to bulb G-4½. Wt., 2 oz.

Stock No.	Mfr's Type	Volts	Amps	Base Fig.	Base Style	Bulb Style	EA.	PKG. OF 10
60 A 7300	PR-2	2.4	.50	C	S.C., F	B-3½	.19	1.16
60 A 7301	PR-3	3.6	.50	C	S.C., F.	B-3½	.19	1.16
60 A 7302	PR-4	2.3	.27	C	S.C., F	B-3½	.19	1.16
60 A 7303	PR-6	2.47	.30	C	S.C., F.	B-3½	.19	1.16
60 A 7304	PR-7	3.7	.30	C	S.C., F.	B-3½	.24	1.44
60 A 7305	PR-12	5.95	.50	C	S.C., F.	B-3½	.19	1.16
60 A 7306	PR-13	4.75	.50	C	S.C., F.	B-3½	.19	1.16
60 A 7367	6	6.4	3.0	F	D.C. Bay.	S-8	.34	1.99
60 A 7307	12	6.3	.15	....	Min. 2-pin	G-3½	.24	1.42
60 A 7308	13	3.7	.30	A	Screw	G-3½	.16	.99
60 A 7309	14	2.5	.30	A	Screw	G-3½	.16	.99
60 A 7310	24E	24	.035	*	Tel. Slide*	T-2	.63	3.74
60 A 7369	24X	24	.035	*	Tel. Slide*	T-2	.63	3.74
60 A 7312	39	6.3	.36	E	S.C. Bay.	T-3¼	.34	1.89
60 A 7313	40	6.3	.15	A	Screw	T-3¼	.14	.81
60 A 7314	41	2.5	.50	A	Screw	T-3¼	.21	1.27
60 A 7315	43	2.5	.50	E	S.C. Bay.	T-3¼	.21	1.27
60 A 7366	44	6-8	.25	E	S.C. Bay.	T-3¼	.14	.81
60 A 7316	45	3.2	.35	E	S.C. Bay.	T-3¼	.17	1.06
60 A 7317	46	6.3	.25	A	Screw	T-3¼	.14	.81
60 A 7318	47	6.3	.15	E	S.C. Bay.	T-3¼	.14	.81
60 A 7319	48	2.0	.06	A	Screw	T-3¼	.21	1.27
60 A 7320	48C	48	.035	*	Tel. Slide*	T-2	.68	4.04
60 A 7321	49	2.0	.06	E	S.C. Bay.	T-3¼	.17	1.06
60 A 7322	50	6-8	1 c.p.	A	Screw	G-3½	.15	.87
60 A 7323	51	6-8	1 c.p.	E	S.C. Bay.	G-3½	.13	.79
60 A 7370	52	14.4	.10	A	Screw	G-3½	.26	1.58
60 A 7324	53	14.4	.12	E	S.C. Bay.	G-3½	.13	.79
60 A 7325	55	6-8	2 c.p.	E	S.C. Bay.	G-4½	.13	.79
60 A 7326	57	14	2 c.p.	E	S.C. Bay.	G-4½	.13	.79
60 A 7328	67	13.5	4 c.p.	E	S.C. Bay.	G-6	.17	1.01
60 A 7329	67K	13.5	4 c.p.	K	Candelabra	G-6	.43	2.51
60 A 7330	81	6-8	6 c.p.	E	S.C. Bay.	G-6	.21	1.26
60 A 7331	82	6-8	6 c.p.	F	D.C. Bay.	G-6	.21	1.26
60 A 9707	93	12.8	1.04	E	S.C. Bay.	S-8	.30	1.79
60 A 7332	112	1.2	.22	A	Screw	TL-3	.16	.99
60 A 6737	137	6.3	.25	E	S.C. Bay.	G-3½	.17	1.06
60 A 6738	157	5.8	1.10	A	Screw	G-6	1.00	5.95
60 A 7334	158	12	.24	H	Wedge	T-3¼	.20	1.14
60 A 7335	159	6.3	.15	H	Wedge	T-3¼	.21	1.26
60 A 7336	222	2.2	.25	A	Screw	TL-3	.16	.99
60 A 7337	223	2.2	.25	A	Screw	FE-3¼	.19	1.16
60 A 7338	224	2.15	.22	J	Special	†TL-2¾	.19	1.16
60 A 7339	233	2.3	.27	A	Screw	G-3½	.19	1.16
60 A 6739	240	6.3	.36	E	S.C. Bay.	G-3¼	.21	1.26
60 A 7340	248	2.5	.80	A	Screw	‡G-5½	.26	1.58
60 A 7373	259	6.3	.25	H	Wedge	T-3¼	.19	1.16
60 A 7341	313	28	.17	E	S.C. Bay.	T-3¼	.30	1.78
60 A 6741	324	3	.19	G	Wire	T-1¼	.58	3.45
60 A 7342	327	28	.04	D	S.C.Mid.F.	T-1¾	.70	4.15
60 A 7343	328	6	.20	D	S.C.Mid.F.	T-1¾	.54	3.25
60 A 7374	330	14	.08	D	S.C.Mid.F.	T-1¾	.78	4.61
60 A 7145	331	1.35	.06	D	S.C.Mid.F.	T-1¾	.84	5.01
60 A 7146	334	28	.04	...	Mid.Groove	T-1¾	.76	3.98
60 A 6742	337	6	.20	...	Mid.Groove	T-1¾	1.55	9.09
60 A 7375	344	10	.014	D	S.C.Mid.F.	T-1¾	1.46	8.46
60 A 7376	345	6	.04	D	S.C.Mid.F.	T-1¾	1.45	8.97
60 A 6743	346	18	.04	...	Mid.Groove	T-1¾	1.26	7.53
60 A 7377	363	14	.20	E	S.C. Bay.	G-3½	.21	1.26
60 A 8900	367X	10	.04	D	S.C.Mid.F.	T-1¾	1.60	9.60
60 A 8901	368	2.5	.20	D	S.C.Mid.F.	T-1¾	.87	5.30

GENERAL-PURPOSE MINIATURE LAMPS (Cont'd)

Stock No.	Mfr's Type	Volts	Amps	Base Fig.	Base Style	Bulb Style	EA.	PKG. OF 10
60 A 6744	370	18	.04	D	S.C.Mid.F	T-1¾	1.26	7.53
60 A 6745	386	14	.08	...	Mid.Groove	T-1¾	1.26	7.53
60 A 7378	405	6.5	.50	A	Screw	G-4½	.27	1.67
60 A 7379	406	2.6	.30	A	Screw	G-4½	.22	1.33
60 A 7380	407	4.9	.30	A	Screw	G-4½	.20	1.22
60 A 7344	425	5	.50	A	Screw	G-4½	.19	1.16
60 A 7346	432	18.0	.25	A	Screw	G-4½	.21	1.26
60 A 7347	433	18	.25	E	S.C. Bay.	G-4½	.26	1.58
60 A 7382	502	5.1	.15	A	Screw	G-4½	.16	.99
60 A 7383	509K	24	.18	K	Candelabra	G-6	.26	1.58
60 A 6600	1133	6	3.91	E	S.C. Bay.	RP-11	.33	2.29
60 A 7384	1383	12	20w	E	S.C. Bay.	R-12	2.65	15.81
60 A 7349	1445	18	.15	E	S.C. Bay.	G-3½	.19	1.13
60 A 7350	1446	12	.20	A	Screw	G-3½	.24	1.45
60 A 7351	1447	18.0	.15	A	Screw	G-3½	.19	1.16
60 A 7353	1458	20	.25	E	S.C. Bay.	G-5	.26	1.58
60 A 7385	1474	14	.17	A	Screw	T-3	.34	2.03
60 A 7354	1477	24	.17	A	Screw	T-3	.52	3.13
60 A 7355	1487	12-16	.20	A	Screw	T-3¼	.24	1.45
60 A 7356	1488	14	.15	E	S.C. Bay.	T-3¼	.26	1.58
60 A 7357	1493	6.5	2.75	F	D.C. Bay.	S-8	1.02	6.08
60 A 7386	1630	6.5	2.75	L	D.C. Pref.	S-8	1.36	8.00
60 A 7359	1768	6	.20	A	Mid.Screw	T-1¾	.90	5.21
60 A 7388	1769	2.5	.20	A	Mid.Screw	T-1¾	.84	5.01
60 A 7360	1813	14.4	.10	E	S.C. Bay.	T-3¼	.24	1.45
60 A 7361	1815	12-16	.20	E	S.C. Bay.	T-3¼	.19	1.16
60 A 7389	1816	13	.33	E	S.C. Bay.	T-3¼	.23	1.38
60 A 7362	1819	28	.04	E	S.C. Bay.	T-3¼	.35	2.07
60 A 7363	1820	28	.10	E	S.C. Bay.	T-3¼	.31	1.84
60 A 7390	1822	36	.10	E	S.C. Bay.	T-3¼	.58	3.48
60 A 7391	1828	37.5	.05	E	S.C. Bay.	T-3¼	.63	3.77
60 A 7364	1829	28	.07	E	S.C. Bay.	T-3¼	.34	2.03
60 A 7392	1835	55	.05	E	S.C. Bay.	T-3¼	.63	3.77
60 A 7365	1847	6.3	.15	E	S.C. Bay.	T-3¼	.17	1.06
60 A 7596	1869D	10	.014	G	Wire	T-1¾	1.10	6.58

100,000-HOUR SUBMINIATURE LAMPS

Last about 12 years! Use where space is critical, service difficult. Solder-dipped leads on wire types. ¼x⅛" dia. *±20%. 1 oz.

Stock No.	Mfr's Type	Volts	Amps. ±10%	Base Fig.	Base Style	Bulb Style	EACH	PKG. OF 10
60 A 7393	680	5	.060	G	Wire	TI	3.10	18.62
60 A 7394	682	5	.060	D	Sub.Mid.F	TI	3.88	23.17
60 A 7395	683	5	.060	G	Wire	TI	3.10	18.62
60 A 7396	685	5	.060	D	Sub.Mid.F	TI	3.88	23.17
60 A 7397	715	5	.115	G	Wire	TI	3.10	18.62
60 A 7399	2128	3	*.0125	G	Wire	TI	4.74	28.23

50,000-HOUR MINIATURE LAMPS

Design life is over 5 years—average life is 50,000 hours. Actual life is determined by environmental conditions: vibration, shock, temperature, voltage fluctuations. Numbers in Bulb Style indicate bulb diameter in eighths of an inch. Av. shpg. wt., 1 oz.

Stock No.	Mfr's Type	Volts	Amps	Base Fig.	Base Style	Bulb Style	EA.	PKG. OF 10
60 A 7400	380	6.3	.04	D	S.C.Mid.F.	T-1¾	1.74	10.61
60 A 7401	381	6.3	.20	D	S.C.Mid.F.	T-1¾	1.10	6.58
60 A 7402	382	14	.08	D	S.C.Mid.F.	T-1¾	1.26	7.53
60 A 7403	755	6.3	.15	B	Min. Bay.	T-3¼	.26	1.58
60 A 7404	756	14	.08	B	Min. Bay.	T-3¼	.34	1.89
60 A 7405	757	28	.08	B	Min. Bay.	T-3¼	.43	2.51
60 A 7406	2180D	6.3	.04	G	Wire	T-1¾	.95	5.64
60 A 7407	2181D	6.3	.20	G	Wire	T-1¾	.52	3.13
60 A 7408	2182D	14	.08	G	Wire	T-1¾	.63	3.77